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Water intake behavior of Gyr dairy heifers fed different inclusion levels of wheat silage

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Abstract

Water is an essential nutrient for productive performance in cattle. In addition to environmental factors, water intake is directly influenced by feed intake and the physical and chemical characteristics of the diet. Therefore, the objective of this study was to evaluate daily water intake (DWI), drinking visits (DV), water intake per visit (WI/V), and time spent at the water trough (TWT) in Gyr dairy heifers fed diets with varying proportions of wheat silage. Thirty-two heifers, with an initial body weight of 357 ± 28.2 kg and a mean age of 797 ± 26 days, were used. The animals were randomly assigned to four treatments (n = 8 animals/treatment) in a completely randomised design. Treatments consisted of isonitrogenous diets with a forage-to-concentrate ratio of approximately 80:20, in which wheat silage replaced corn silage at 0, 33, 67, and 100% of the forage dry matter. Means were analyzed using the GLM procedure and compared by Tukey's test at a 5% significance level. No differences were observed among treatments for any of the evaluated variables. It was concluded that, under the conditions of this study, replacing corn silage with wheat silage did not affect water intake or water intake behavior in the animals.

Introduction

Water is an essential nutrient for sustaining the life, health, and productive performance of cattle (Wagner and Engle 2021). It plays a fundamental role in several physiological processes, including thermoregulation, digestion, the transport of nutrients and metabolites between the intra- and extracellular compartments, and the excretion of metabolic waste (Golher et al. 2021; Wagner and Engle 2021). Voluntary water intake is strongly influenced by dry matter intake (DMI) and by the physical and chemical characteristics of the diet, particularly dry matter and fiber concentrations (Cardot et al. 2008; Appuhamy et al. 2016; Wagner and Engle 2021).

Compared with corn silage, wheat silage generally has higher dry-matter and fiber concentrations due to physiological differences between the crops (Harper et al. 2017; Álvarez-García et al. 2023; Gomes et al. 2025). These characteristics may increase the need to moisten the feed bolus, stimulate saliva production, and maintain adequate ruminal conditions (Berchielli et al. 2011; Havekes et al. 2020), thereby favouring water intake. Despite this relationship, voluntary water intake and water-intake behavior have received less attention in ruminant nutrition studies than traditional evaluations of feed intake and animal performance.

Therefore, it was hypothesized that replacing corn silage with wheat silage would increase water intake and alter water intake behavior in Gyr dairy heifers fed diets with varying proportions of wheat silage.

Materials and Methods

The experiment was conducted at the Agricultural Research Company of Minas Gerais (EPAMIG), Getúlio Vargas Experimental Station, Western Unit, in Uberaba, Minas Gerais, Brazil. According to the Köppen climate classification, the region has a tropical savanna climate (Aw) (Alvares et al. 2013). Thirty-two Gyr dairy heifers (*Bos taurus indicus* L.) with an initial body weight of 357 ± 28.2 kg and a mean age of 797 ±

26 days were used. The animals were randomly assigned to four homogeneous groups (n = 8 per treatment) in a completely randomized design and housed in collective pens equipped with electronic feeders and water troughs (Ponta/Intergado®, Contagem, Minas Gerais, Brazil) for 113 days, with the first 21 days used for adaptation to the facilities and experimental diets.

The diets had a forage-to-concentrate ratio of approximately 80:20 and were formulated using the Large Ruminant Nutrition System (LRNS). Treatments involved replacing corn silage with wheat silage (WS) at 0, 33, 67, and 100% of the forage dry matter (Table 1). Diets were offered ad libitum twice daily, at 0800 and 1600 h, with approximately 10% refusals.

Table 1
Ingredient proportions and chemical composition of the diets containing different inclusion levels of wheat silage.

Ingredients (% DM)	**Wheat silage inclusion levels**			
	0%	**33%**	**67%**	**100%**
Corn silage	79.45	54.63	27.68	0.00
Wheat silage	0.00	24.73	51.57	79.12
Feed-grade urea	1.55	1.14	0.71	0.28
Concentrate*	19.00	19.50	20.04	20.60
Chemical composition[1]				
Dry matter (DM, %)	37.92	38.85	39.93	41.10
Crude protein (CP, % DM)	12.60	12.56	12.57	12.59
Neutral detergent fiber (NDF, % DM)	39.35	41.82	44.50	47.24
Physically effective neutral detergent fiber (peNDF, % DM)	24.60	30.60	31.00	37.00
Acid detergent fiber (ADF, % DM)	24.98	26.60	28.34	30.13
Ash (% DM)	7.52	6.89	6.24	6.57
Ether extract (EE, % DM)	2.71	2.71	2.72	2.72

[1] DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; peNDF = physically effective neutral detergent fiber; ADF = acid detergent fiber; Ash = mineral matter; EE = ether extract.

* Concentrate composition: 83.5% ground corn, 12.0% soybean meal, and 4.5% mineral premix for heifers.

[Insert Table 1 **here]**

Feed and water intake were automatically recorded at each visit of the animals to the electronic equipment. Initially, individual records from each visit were aggregated to obtain daily values for each animal. From these records, the following variables were derived: dry matter intake (DMI; kg/day); daily water intake (DWI; kg/day), defined as the sum of water consumed across all visits to the water trough throughout the day; drinking visits (DV; visits/day), defined as the daily number of visits to the water trough with effective water consumption; water intake per visit (WI/V; kg/visit), defined as the average volume of water consumed per visit; and active time at the water trough (TWT; min/day), defined as the daily time effectively associated with water consumption. For each variable, the average of the daily values recorded for each animal throughout the experimental period was considered.

Meteorological variables were monitored and recorded by the automatic weather station at the Federal University of Triângulo Mineiro (UFTM), Univerdecidade Campus, Unit II, in Uberaba, Minas Gerais, Brazil. The data were provided by the Brazilian National Institute of Meteorology (INMET; Station A568). The temperature–humidity index (THI) was calculated using the method of Buffington et al. (1981) (Table 2).

Table 2
Meteorological variables monitored during the experimental period.

Meteorological variable	**Mean**	**Minimum**	**Maximum**
Relative humidity (%)	78.32	60.6	100.0
Air temperature (°C)	25.19	14.3	34.1
Temperature–humidity index (THI)*	75.00	68.63	79.79

* THI = temperature–humidity index, calculated according to the equation proposed by Buffington et al. (1981): THI = (0.8 × AT) + (RH/100) × (AT − 14.4) + 46.4, where AT = air temperature (°C) and RH = relative humidity (%).

[Insert Table 2 **here]**

The data were screened for outliers, defined as observations outside the interval corresponding to the mean ± 3.5 standard deviations. Residual normality was assessed, and the variables were analysed using the GLM procedure in SAS (SAS Institute Inc., Cary, NC, USA), accounting for the treatment effect. Means were compared using Tukey's test at a 5% significance level.

Results

During the experimental period, the mean air temperature was 25.2°C, the mean relative humidity 78.3%, and the mean temperature–humidity index (THI) was 75.0 (Table 2).

Replacing corn silage with wheat silage did not affect the heifers' dry matter intake (DMI) (P = 0.1872; Fig. 1), despite increases in the diets' dry matter, neutral detergent fibre (NDF), and physically effective neutral detergent fibre (peNDF) concentrations as the proportion of wheat silage increased (Table 1).

Likewise, no differences were observed among treatments for daily water intake (DWI), drinking visits (DV), water intake per visit (WI/V), or active time at the water trough (TWT) (P > 0.05; Table 3).

Table 3
Water intake behavior characteristics of heifers fed diets containing different inclusion levels of wheat silage.

Characteristics [1]	Wheat silage inclusion levels					
	0%	33%	67%	100%	SEM	P-value
DWI (kg/day)	20.55	21.16	19.53	20.16	1.70	0.9220
DV (visits/day)	4.70	4.16	4.17	4.46	0.29	0.5163
WI/V (kg/visit)	4.57	5.18	4.69	4.74	0.48	0.8211
TWT (min/day)	13.73	11.53	10.61	11.53	1.52	0.5248

[1] DMI = dry matter intake; DWI = daily water intake; DV = drinking visits; WI/V = water intake per visit; TWT = time spent at the water trough while consuming water; SEM = standard error of the mean.

[Insert Fig. 1 **here]**

[Insert Table 3 **here]**

Discussion

The absence of differences in DWI and TWT is likely due to the similar DMI observed across treatments. Dry matter intake is a recognized biological and mathematical predictor of voluntary free water intake in cattle because it is directly associated with the water required for digestive and metabolic processes (Cardot et al. 2008; Appuhamy et al. 2016; Wagner and Engle 2021). Therefore, because DMI remained similar across diets, it was also expected that the animals' water requirement would not change substantially.

Although replacing corn silage with wheat silage increased the dry matter, NDF, and physically effective neutral detergent fiber (peNDF) concentrations of the diets (Table 1), these changes were insufficient to modify the water intake behavior of the Gyr heifers. Diets with higher fiber concentrations generally increase the need for chewing, saliva production, and water demand to maintain ruminal fermentation (Berchielli, Pires, and Oliveira 2011). However, under the conditions of this study, the physical and chemical differences between the forages were not pronounced enough to alter DWI, DV, WI/V, or TWT.

Conclusion

Whole-plant wheat silage can completely replace corn silage in the diet of Gyr dairy heifers without compromising water intake or water-intake behavior.

Declarations

Funding

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Conflict of Interest

The authors declare no financial or non-financial conflicts of interest in relation to this work.

Author Contributions

Diorgenes Steve Soares de Lisboa: Conceptualization, formal analysis, and writing. Edilane Aparecida da Silva: Investigation, writing, data curation, and editing. Angelo Herbet Moreira Arcanjo: Investigation, writing, review, and editing. Fernando Oliveira Franco: Review and editing. Eduardo Vasconcelos dos Santos: Writing and review. Bianca Matos Afonso: Writing and review. Alvimara Felix dos Reis: Methodology and review. Livia Loiola dos Santos Féres: Review and translation. Jessica Morais Malheiros: Supervision, methodology, writing, review, and editing. Lenira El Faro Zadra: Supervision, review, and editing.

Data Availability

The datasets generated and/or analyzed in the current study are available from EPAMIG upon reasonable request.

Ethics Approval

All procedures involving animals were approved by the Animal Ethics Committee of EPAMIG (CEUA/EPAMIG) under protocol No. 03/2022. Informed consent was obtained from the owners of the animals, and all animals received care in accordance with high standards of animal welfare throughout the study.

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Figures

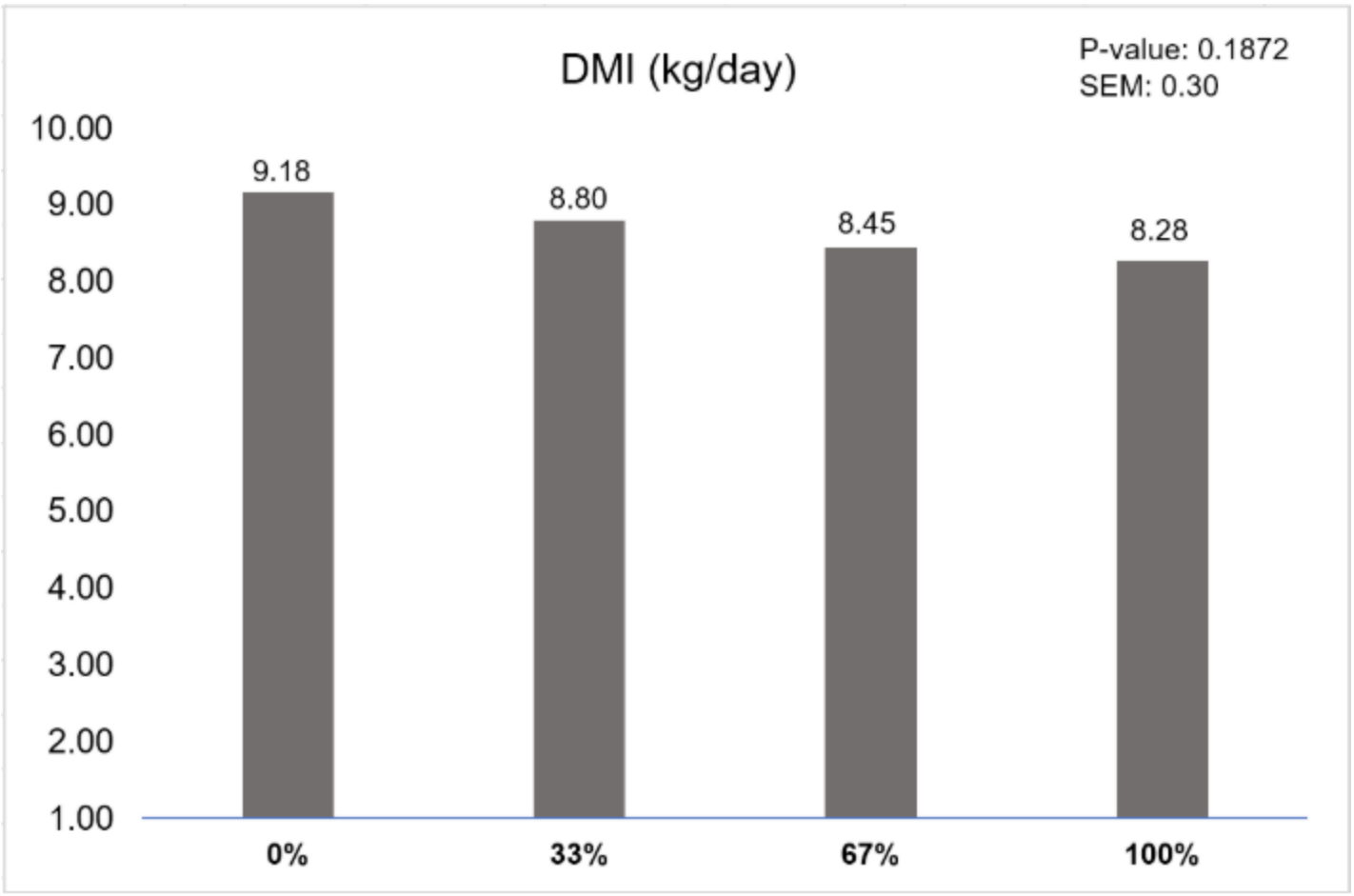


Figure 1

Legend not included with this version